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Air Conditioning Trends in Europe Compared to the U.S.A.

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AIR CONDITIONING TRENDS IN EUROPE COMPARED TO THE USA

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1. INTRODUCTION

Air conditioning in the USA compared to Europe is quite different, not only because of the dissimilar climate and exclusive application to commercial buildings, hospitals, and industrial plants in Europe, but also because of the contrasting definition. Across Europe, air conditioning systems are similar to the German standard definition having four different controlled thermodynamic air treatment functions /1/. If this basic requirement is not fulfilled the system may serves only ventilation duties. In Europe, air conditioning of occupied spaces is furthermore not only a synonym for air cooling but specifies human comfort levels much more precisly than air conditioning does in the USA.

2. COMFORT REQUIREMENTS

The comfort level in occupied spaces, i.e. commercial office buildings, depends on a number of conditions. Some of them may not be influenced by an air conditioner, e.g. the activity level, the type of clothes, and the health of the occupants. However, an air conditioning system may effect the remaining comfort influence parameters. These are the conditions of the room air, i.e. its temperature, humidity, velocity, and cleanliness; and the building properties, i.e. temperature of the surrounding walls, radiation, light and sound levels.

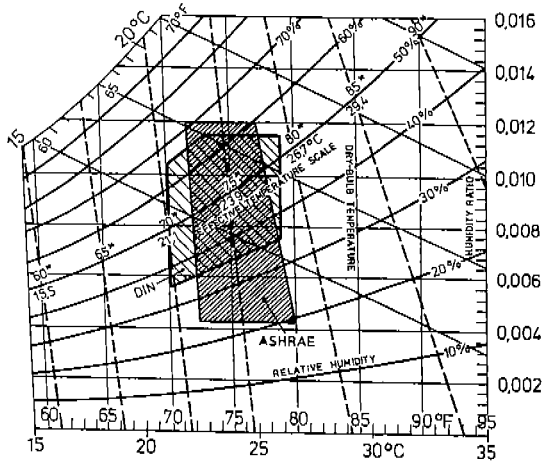

Fig. 1 - Comfort envelope for the United States and Europe.

Nonetheless, the room air temperature and relative humidity level are often the only major concern to system designers. During cooling periodes, the air conditioning system shall provide room air with an average temperature of 24 °C (75 °F) and a relative humidity level of 40% in the US; or approximately 23 °C (74 °F) and 50% RH in Europe.

At elevated outdoor air temperatures, exceeding 30°C (86°F), the room air temperature may rise to 26°C (79°F) in both, European and American office buildings and may not drop below 18°C (64°F) during heating operation. The relative humidity shall, depending on the room air temperature, not be lower than 20% and not exceed 70% in the US /2/; or between 35% and 65% in Europe. In summary, the comparison of the comfort range existing in the two continents (shown in Figure 1), demonstrates the wide accepted humidity range and narrow temperature band in the US in contrast to European comfort standards.

Regarding the accepted interior sound level, there are distinct values recommended in Europe, varying from 25 dB(A) to 45 dB(A) depending on the type of room (concert hall or large office). In the USA, on the other hand, it is common practice to exceed a sound level of 50 dB(A) (predominantly with window units) in order to detect operation of the air conditioner. A high air velocity is also used in the US to ascertain whether or not the air conditioner is working. The high air velocity is often felt comfortable as a "fresh breeze" when the outdoor temperature and humidity level is very high.

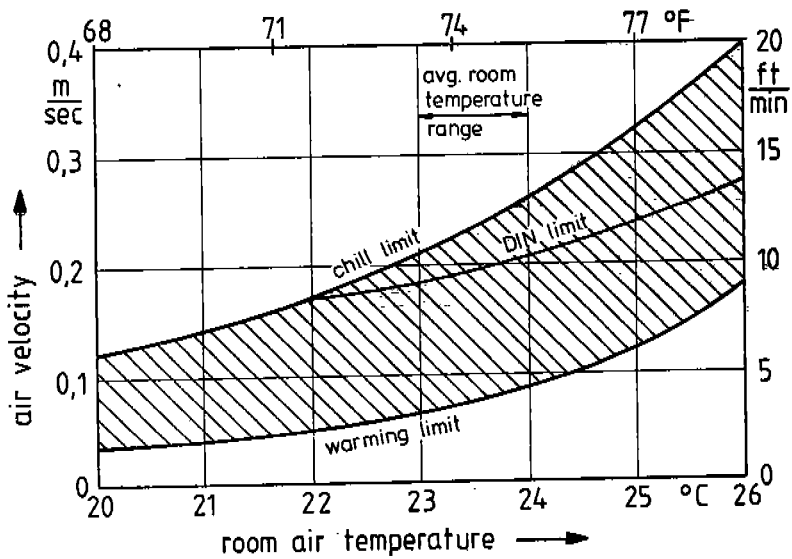

Fig. 2 - Velocity limits in European comfort zones /3/.

In general, accepted air velocities are much higher in the United States than they are in Europe and are not very critical, even though the US design velocities vary only from 0.15 m/s to 0.25 m/s (30 ft/min to 50 ft/min). These values are comparable with the maximum velocities allowed in Europe, shown as the "DIN curve" in Figure 2 as a function of the room temperature. However, it is recommended not to exceed 0.15 m/s (30 ft/min) in Europe /1/ and 0.20 m/s (40 ft/min) in the United States /2/ having a room temperature of approximately 24°C (75°F). Those recommended velocities are, of course, far exceeded in the vicinity of air outlets.

3. AIR CONDITIONING SYSTEMS

How much an occupant is exposed to the high velocity in the vicinity of an air outlet depends not only on the floor layout and the physical positioning of work stations but also on the design of the air distribution system. In the United States, where air conditioning is primerily designed for cooling, almost all central air conditioners are single duct, low pressure, variable volume (VAV) systems with air supply from the ceiling. Linear or square diffusers are predominantly used to supply the conditioned air, located either in the center of the office or towards the window. For heating purposes, a separate slot may be installed close to the window to compensate for the cold draft. The flow pattern to be achieved with such an installation is shown in Figure 3.

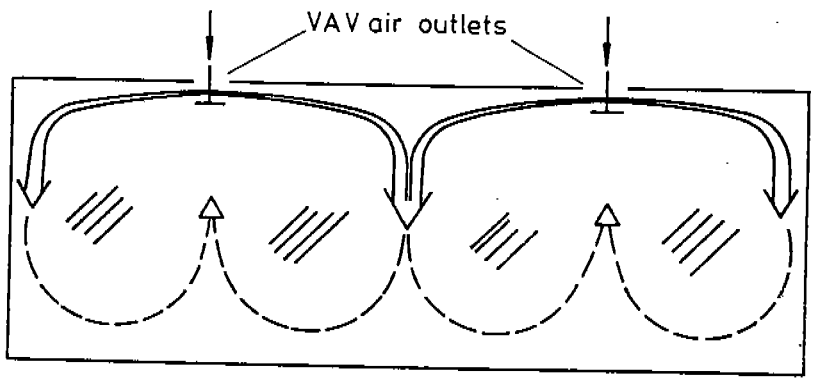

Fig. 3 - Room air flow pattern during cooling in a typical US office.

At low air volumes, this flow pattern may not be achieved any longer since the impulse (kinetic energy) of the supply air can not be kept constant. A constant impuls would require four times the velocity at the half volume flow rate. If the volume flow rate is reduced extensively, the ventilation rate may not be satisfactory and the VAV system is being blamed for the "tight building syndrome". In Europe, where VAV systems are inreasingly be used in commercial office buildings, the minimum reduction of the volume flow rate is restricted to the half of the design value. VAV systems, which represent more than 50% of the commercial building installations in Europe today, are designed for a duct velocity of no more than 18 m/s (60 ft/s), whereas the constant volume systems (mostly used in industrial applications) are designed for a maximum velocity of 12 m/s (40 ft/s), although old systems may still opperate at 25 m/s (80 ft/s).

The total design volume flow rate in the United States averages to 14.6 m^3/h per m^2 of office floor area (0.8 cfm/ft^2) with a fresh air content of approximately 10%. Using an average floor area of 12.5 m^2 (125 ft^2) per person, he will get only 17 m^3/h (10 cfm) of fresh air, whereas the European person gets at least 20 m^3/h fresh air.

During cooling, such "air-only" systems provide air velocities within the recommended limits due to air induction prior to the occupants skin contact. However, in the heating mode much higher velocities are required to force the light, hot air, with moderate induction, to the office floor in order to provide comfort. In this case, the recommended air velocity of 0.20 m/s (40 ft/min) is far exceeded.

Such high air velocities are inconceivable in Europe and would lead to further complaints about air conditioning. Futhermore, the climate in Europe requires the design of air conditioning systems to be focused on heating duties. Therefore, ceiling air outlets in European central VAV air conditioning systems are almost only applied to the interior zones of large offices. Instead, VAV induction units with hydronic reheaters are utilized for the office building perimeter with the supporting natural convection effect. Air jet stabilizers from the ceiling may be used if the flow pattern is disturbed by curtains or various structured ceilings. A typical design flow pattern of a European office is shown in Figure 4.

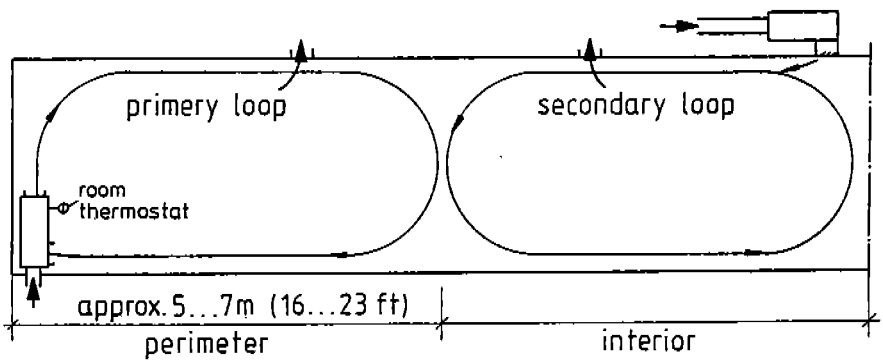

Fig. 4 - Room air flow pattern in a typical European office.

In addition to the satisfaction of desired comfort levels, the VAV induction air conditioners offer operating cost advantages over air-only systems, individual Temperature control at each terminal, small ducts used for primary air only, prevent from odor transmission between rooms, and provide radiant heating during unoccupied periods.

The radiant heating is being used during night set back and weekend schedules when no fresh air is needed. The heat is supplied by hot water only using the induction units as a radiator. During the summer, night set back and weekend schedules are being realized by hourly usage of the system. In the United States, the air conditioner is generally shut off unless the outdoor conditions do not permit such procedure. During the heating periode, warm air may always be supplied, although the temperature level is reduced to 18 ^{o}C (65 ^{o}F).

4. AIR CONDITIONING APPLICATIONS

For cooling, a refrigeration unit must be selected to remove the access heat from occupied spaces. The decision whether to use a direct expansion (DX) or a chilled water system is often arbitrary and does not always depend on the cooling capacity. A wide tonage range, in which either system may be applied, is available for the US design engineer. In general, DX systems are being used at cooling capacities of less than 210 kW (60 ton) and chilled water systems above 530 kW (150 ton). In Europe, all refrigeration units supplying more than 60 kW (17 ton) cooling capacity are chilled water systems. This large discrepancy in liquid chiller application is due to the different economics in the two continents, which also determines the utilization of heat recovery systems.

Heat recovery systems in Europe are widely applied to central air conditioning installations, using water as a secondary heat transfer fluid between the supply and return air. Some heat pipes and regenerative heat exchangers (wheels) are beeing used in both continents, although there are not too many installations in the United States. In a few special cases double bundle heat reclaim centrifugals are installed. This is the result of a target pay back period of two to three years, which can be met only with systems operating on a very high fresh air content.

US hospitals for example, are suitable for air-to-air heat recovery systems since their clean operating rooms require 100% fresh air. The remaining building can be satisfied with standard equipment, suitable for each individual zone, e.g. bedrooms in European hospitals are equipped with air-water-systems, delivering the air underneath the window. Thus, good control of the room air condition is provided during the night, when the air flow rate is low and free convection of the heat exchanger can be utilized.

Clean room technology today is not only applied to operating rooms, but also to the industry, in particular to microchips manufacturing plants. The laminar flow of either horizontal or vertical layers of filtered air is subject of very strong requirements regarding the number and size of particals. In the United States this technology is very advanced and the control of the flow pattern and dust attained very high levels.

5. OUTLOOK

In Europe, more attention will be devoted to the design of air conditioning systems with the focus on the attained comfort level to reestablish the faith in air conditioning. Futhermore, the operating cost must be minimized, using water as the heat transfer fluid for reduced pumping power and capitalizing from heat recovery systems. The operating cost also forces the American design to change.

Due to the American electric utility pressure and their incentives, the trend toward storrage systems is beginning, using water as the heat transfer medium to several self contained water cooled packages in high rise buildings. In general, unitary equipment and water source heat pumps are advancing in the United States and are being applied to buildings which were traditionally equipped with central systems.

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3. F. STEIMLE, "Das hochwärmegedämmte Haus als Voraussetzung neuer Heiztechnologien." (The well insulated house as the prerequisite for new heating technologies), Zeitschr. f. WKSB 30, No.19 (1985)

COMPARISON DE LA CONDITIONNEMENT ENTRE L'EUROPE ET ETATS-UNIES

RESUME: La technique de conditionnement d'air est tres different entre les Etats-Unies et l'Europe. Ce n'est pas seulement la difference de clima entre Amerique et l'Europe mais aussi la difference de confort et des fonctions thermodynamiques utilisees dans les installation. En Europe conditionnement d'air realise tres clairement le confort human et pas seulement le refroidissement de l'air. Les installations dans certains immobles sont aussi tres differents et il est necessaire de comparer precisement.